Report of the NSAC RIA costing Sub-committee

- Background
- Baseline Facility Scope
- Cost Basis
- Cost Estimate (TEC)
- Annual operating budget
- R&D, Pre-ops (TPC)
- Committee's conclusions
- Committee's General comments

Background

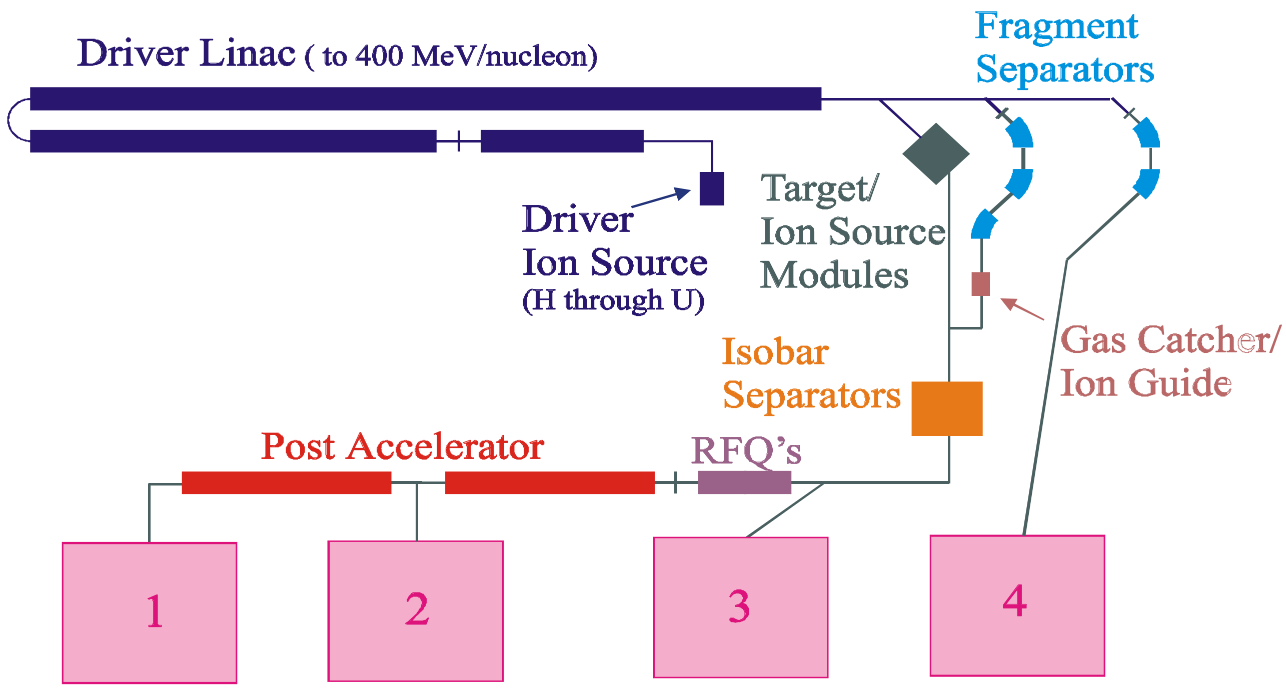
- Membership
  - Jim Beene ORNL
  - Mike Harrison BNL (chair)
  - Christoph Leeman Jlab
  - Jay Marx LBNL
  - Thom Mason SNS
  - James Symons LBNL (ex-officio)
  - Denis Kovar DOE (observer)
- The review lasted 1+ days at ANL on Jan 10/11. The technical design of the facility was not scrutinized only costs.
- Project scope as in Grunder + fast fragmentation beam capabilities and associated experimental facilities + R&D & Pre-ops i.e. a TPC as well as a TEC
- Cost estimate was a joint MSU/ANL collaborative effort using a 'none site specific metric'

Baseline Facility Schematic

2 ISOL targets &
2 fragmentation
targets with rapid
beam switching

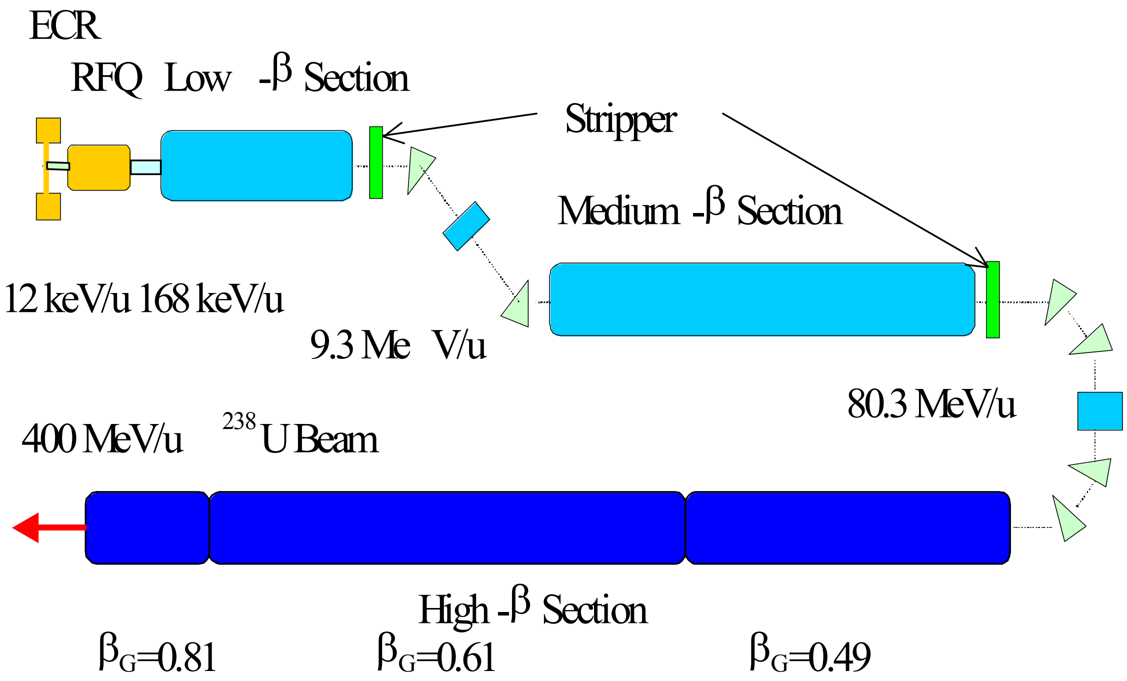
CW operation

Simplified Schematic Layout of the Rare Isotope Accelerator (RIA) Facility



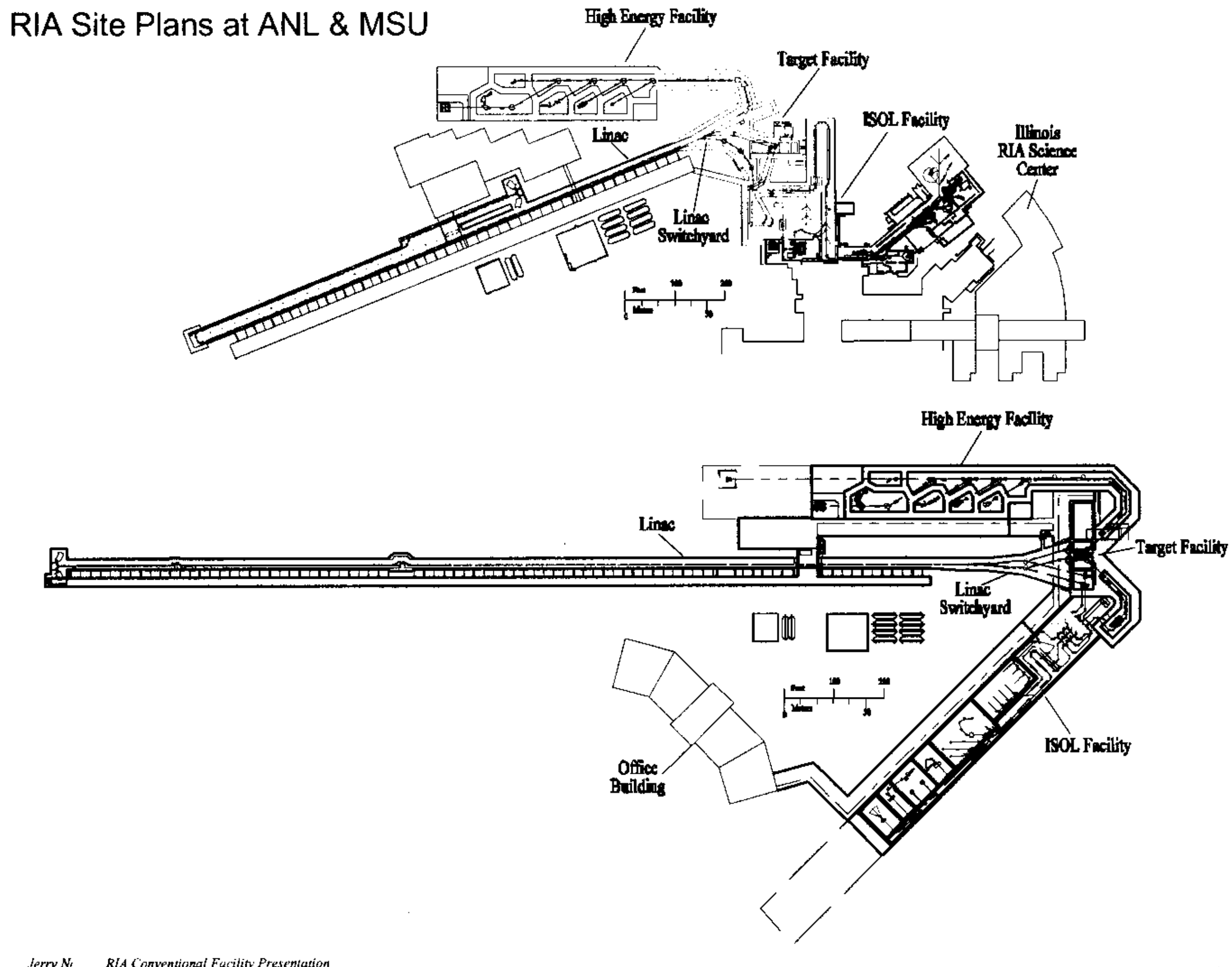
Experimental Areas:
1: < 12 MeV/u 2: < 1.5 MeV/u 3: Nonaccelerated 4: In-flight fragments

Driver Linac



- All rf cavities use superconducting technology. High-beta structures based on SNS design. Medium & low beta derived from existing ANL designs

The facility footprint at MSU or ANL is similar but not identical



Proposed RIA Layout

Cost Basis - Global

Cost Basis

- **Specific Sources**
  - **WBS 1 (Central Systems)**
    - Cryogenic Systems – Jlab estimate
    - Controls – Recent NSCL EPICS and PLC Upgrade
  - **WBS 2 (Civil Facilities)**
    - Civil – ANL and MSU architectural firms and contacts
  - **WBS 3 (Driver Systems)**
    - Front End – ANL, LBL estimate
    - Low Beta Linac – ANL and AES w/industry quotes
    - High Beta Linac – Jlab estimate / SNS elements

John Vincent – RIA Cost Overview – 1/10/2001

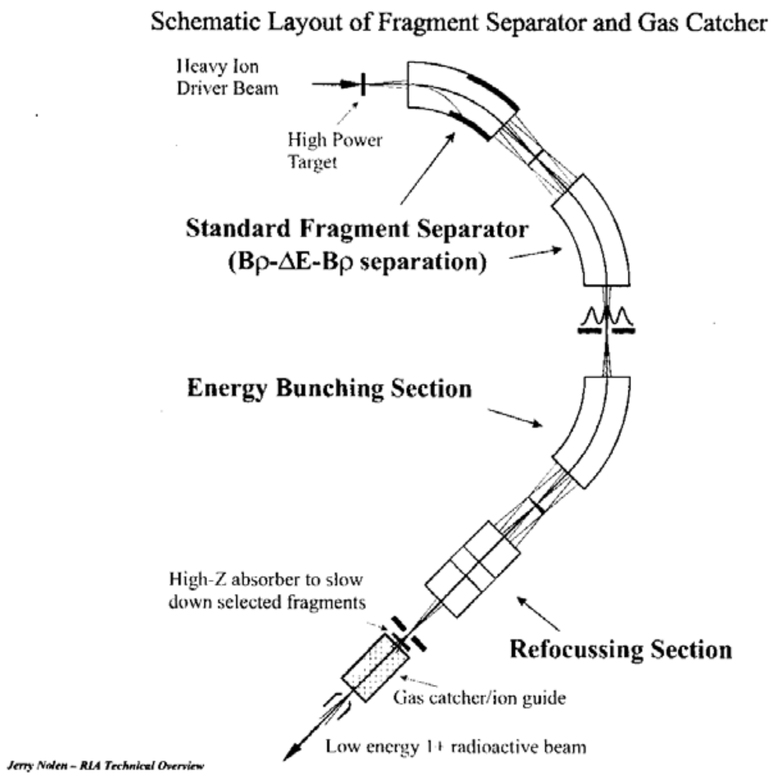
Cost Basis

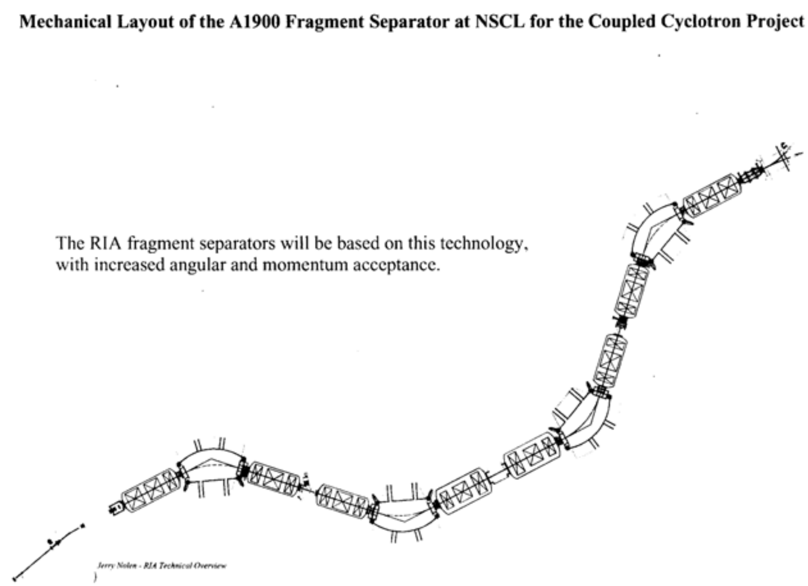
- **Specific Sources (cont.)**
  - **WBS 4 (Experimental Systems)**
  - Magnetic Selection and Transport Elements – NSCL CCP Database
  - ISOL Selection and Transport Elements – ANL w/many catalog items
  - ISOL Detector Systems – Trust fund based on ISOL instrumentation white paper
  - High Energy Detector Systems – Trust fund based on High Energy instrumentation white paper

John Vincent – RIA Cost Overview – 1/10/2001

- Most systems are based on existing technologies at ANL, MSU, Jlab, SNS & TRIUMPF

Cost Basis - Fragment Separator

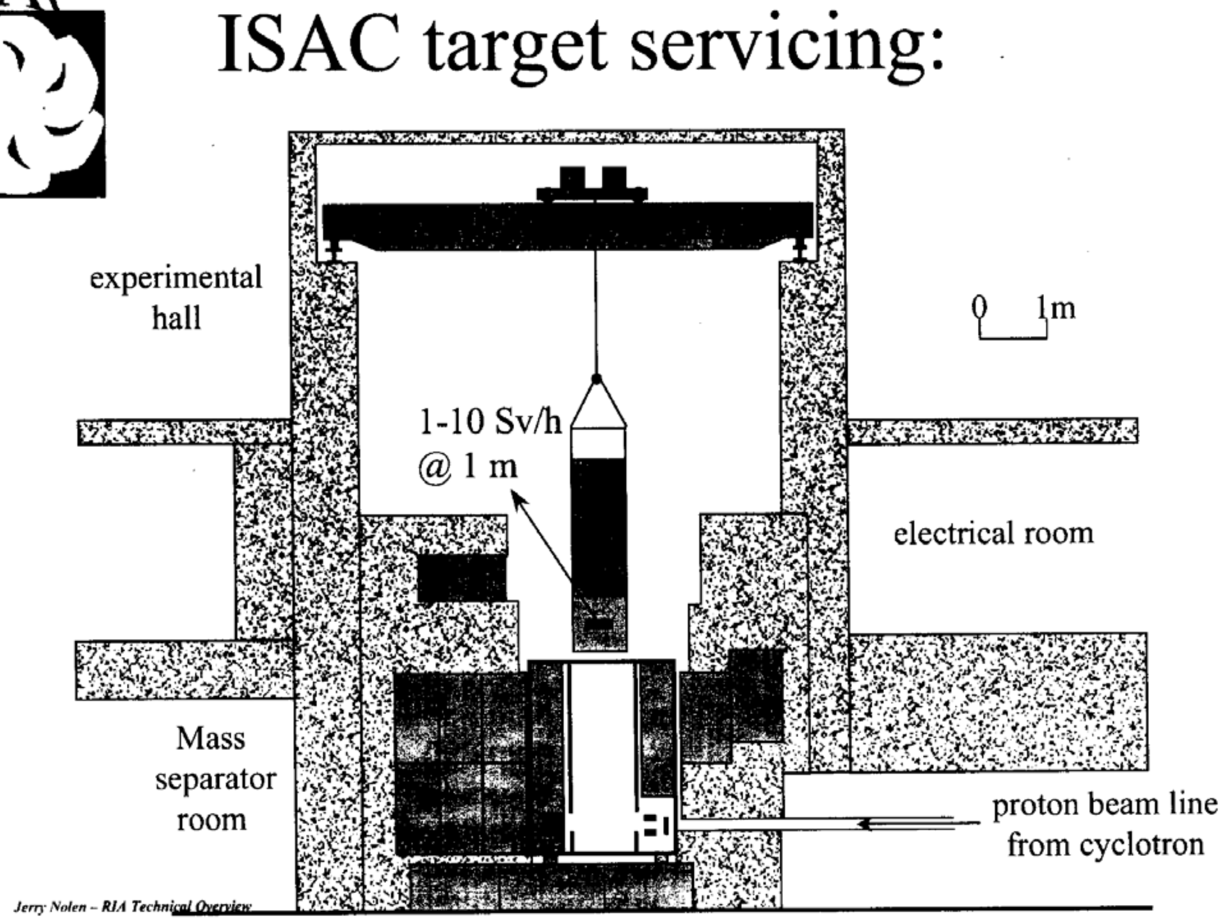




- Fragment separator based on new design + NSCL technology + MSU magnet database

Cost Basis - Targetting

- Concept for target area based on ISAC at TRIUMPF



Cost Basis - Methodology

- Standard WBS breakdown down at component level for major technical items e.g. drift tube linac section

Cost Breakout for Spoke-cavity Linac Section

			CM unit costs
1.3 Driver Accelerator Systems			
1.3.2 Drift Tube Linac Section			
1.3.2.2 Post-stripper Drift-tube Section			
1.3.2.2.3 Cryomodule #20-31 (0.38 β Cavities)	$12,671		
1.3.2.2.3.1 Cavities		$6,625	$1,056
Fully dressed cavity cost of 69 k$ = bare cavity (54 k$) + tuners & power coupler			
1.3.2.2.3.2 Cryostats		$2,909	
1.3.2.2.3.3 Internal Cryogenics		$504	
1.3.2.2.3.4 Focusing Magnets		$420	
1.3.2.2.3.5 Vacuum Systems		$1,032	
1.3.2.2.3.6 Cavity Processing & Cryostat Assembly		$1,182	
1.3.2.4 Cryomodule Installation & Checkout in Tunnel	$362		$12
1.6 RF Systems			
1.6.2 Drift Tube Accelerator Systems			
1.6.2.4 Circular Cyomodule RF Power Systems	$9,364		$360
1.6.2.4.1 High Level RF Power		$3,150	
1.6.2.4.2 Low Level RF Power		$4,676	
1.6.2.4.3 Miscellaneous Hardware		$1,538	
Cost per Cryomodule - w/o contingency			$1,428

Costs are given in k$

Kenneth Shepard *RIA Cost Review: Driver Linac – Drift-tube Section* *10 January 01*

Cost Estimate Accuracy

- Very small percentage of the total are WAG's
- Vendor estimates + similar systems from other labs ~50% of the TEC
- Systematic WBS roll-up for major systems

Approximate Cost Distribution

Rough Eng. Est.	Eng. Est.	Vendor Est.
~25 M$	~483 M$	~127 M$ (Civil) ~ 60 M$ (Other)

~ 25M$ + 483 M$ + 187 M$ = 695 M$

3% + 70 % + 27% = 100 %

- Fraction that is *easily* related to other labs.

o Central Controls	~14 M$	SNS
o Front End	~11 M$	SNS
o High Beta Linac	~43 M$	SNS
o Target Systems	~27 M$	ISAC
o Beam Transport	~37 M$	NSCL
Total	**~132 M$** **(~19 %)**	

~23 % excluding civil

The RIA TEC

				Experimental Facilities				
	Management, Computing, and Controls	Cryogenic Plant and Distribution	Driver	Exp. Safety and Control Systems	Target Systems	ISOL Facilities	High Energy Facilities	Total
Central Facilities	$44.3	$46.5						**$90.8**
Civil and Utilities	$28.1	$4.7	$27.0		$18.9	$26.2	$21.6	**$126.5**
Driver			$213.5					**$213.5**
Experimental Facilities				$9.6	$45.8	$124.3	$83.8	**$263.5**
MSU Total	**$72.5**	**$51.2**	**$240.4**	**$9.6**	**$64.6**	**$150.5**	**$105.4**	**$694.3**
- ANL Atlas						-$38.7		-38.7
- ANL Other (e.g. civil)								-11.6
ANL Total						**$111.8**		**$644.0**

Driver Linac

- Technical specifications determined by the ISOL task force sub-committee and remain essentially unchanged since the Grunder report.
- Big cost element; $214M.
- Extensive use of srf technology based on the ANL & JLAB designs. JLAB designs identical to the SNS cavities.
- Beam quality requirements modest by most Linac standards.
- Cost of the Driver Linac has not significantly changed since the ISOL task force where it was reviewed in some depth.

Experimental Facilities

- Concepts presented for the beam production facilities and experimental apparatus cover the full range of capabilities articulated by the RIA research community. (Can imagine increased demand for instrumentation funding while RIA is under development.)
- Costs generally based on recently built facilities.
- ISOL target based on ISAC at TRIUMF. 'Relevant, recent and reasonable'
- Caution about (constantly changing) regulatory requirements.
- Production areas likely to be a hazard category III nuclear facility.
- Some concern about liquid Li targets. Different requirements from the fusion program.
- 'Trust fund' approach is now common for a facility of this scale & type.

Civil Construction

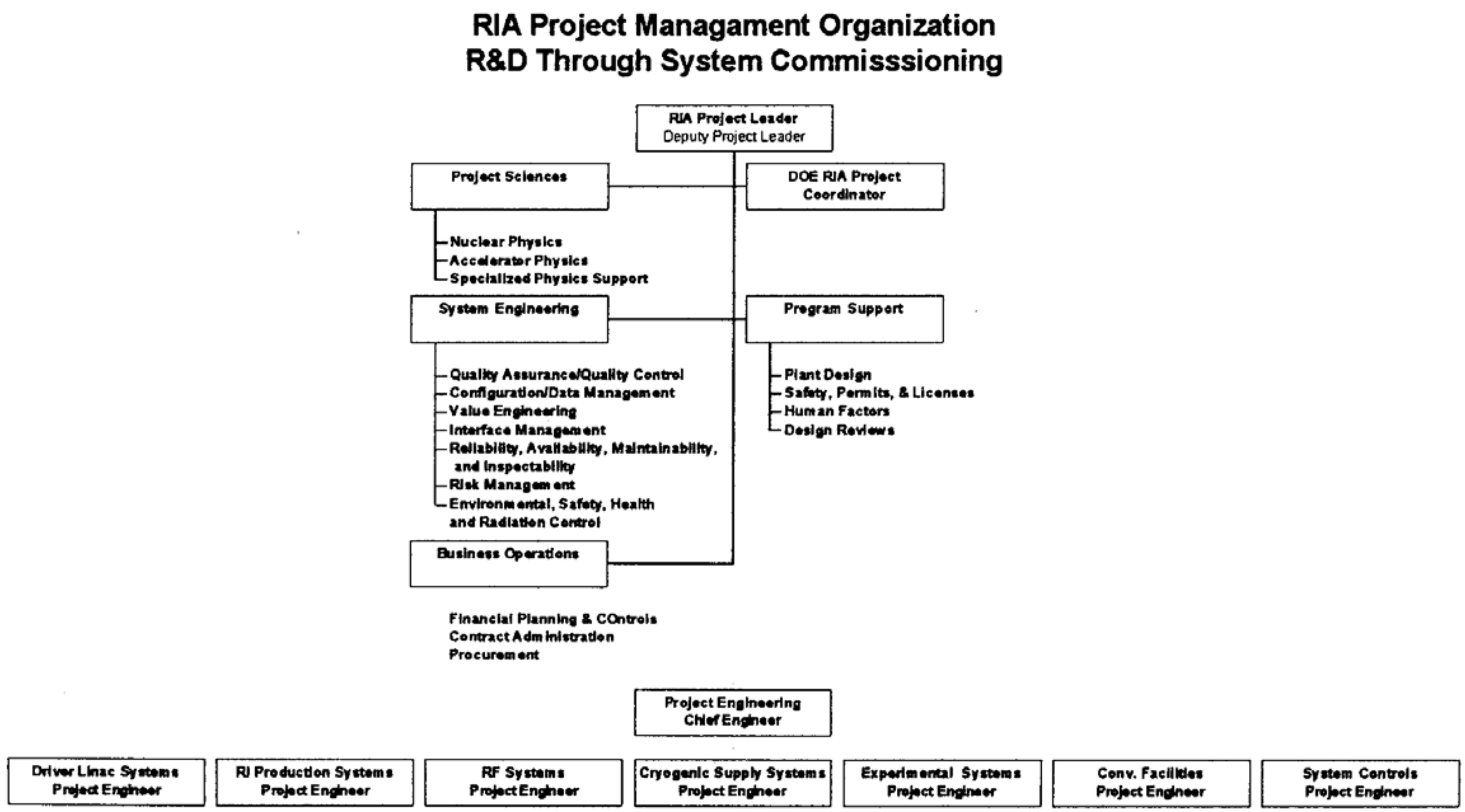
- Building specifications included size, utilities and special requirements i.e. not generic buildings.
- Independent estimates of similar buildings tended to agree well between both ANL internal estimates, and ANL & MSU estimates.
- Bottom line between MSU & ANL agreed to ~5% although detail varies between the 2 estimates.
- Cost per square foot in the range of $200 - $600.
- Civil construction assessed at 20% contingency. Historically both ANL and MSU have constructed similar facilities within 20% of the estimated cost.
- Probably the biggest uncertainty in these costs would be the probability that the footprint might change. No obvious reasons why this would happen.

Central Facilities

- Project management manpower estimated at 28 FTE's derived from a conceptual management structure: less than SNS, slightly more than RHIC i.e. consistent with TEC. Assumes a 5 year profile for these people results in ~$30M.
- Project management tends to be a 'standing army' and costs would tend to vary with length of the Project.
- Cryogenic unit costs based on the SNS (heavily reviewed) cost estimate. Within a few months bids will be opened. Might be able reduce contingency at that time.
- Cryogenic load from the various system components, 50% excess cryogenic capacity as safety margin. Transfer lines from the footprint.
- Control system based on NSCL ~$15M, 12 FTE's.

Cost Element - Project Management

Figure 8: RIA Project Management



Annual Operating Costs

- Total annual operating costs estimated at $65M in two independent estimates
- MSU using functional requirements (based loosely on JLAB), ANL using ATLAS + other labs
- Difference in FTE costs between MSU/ANL. MSU generally cheaper due to different indirect charge basis
- Bottom line consistent between both estimates

Area	*FTE*	*COST* (M$)
Accelerator Operations		
Accelerator Physics	15	
Cryogenics	20	
Vacuum, Alignment, & Installation	20	
SRF	15	
Controls & Electronics	30	
Control Room Staff	25	
Ion Sources	5	
RF	30	
Safety	30	
ME & Mach. Shop	25	
Maintenance	15	
Total Personnel	**230**	**34.5**
Electrical		**7**
Procurements		**6.5**
Total Accelerator Operations		**48**

Table VIII: Research Operations

Area	*FTE*	*COST* (M$)
Experimental Operations		
Staff	30	
Installation & Systems Support	15	
Control, Diag., & Data Acquisition	10	
Detectors, N. Electronics, Targets	10	
User Services	5	
Postdocs	20	
Total Personnel	**90**	**13.5**
Procurements Total		**3.5**

Annual Operating Costs

- Sub-committee more comfortable with MSU's manpower assessment (320) than ANL's (253).
- Personnel costs of $48M seemed low from either lack of manpower ANL or 'cheap' FTE's at MSU.
- Couldn't find a facility Director and associated admin staff, no facility development activities, no data processing and computing. Possibly supported by indirect charges.
- M/S budget of $17M included $5M equipment, $7M power (5c/kWh), $1.5M cryogens. Seemed 'on the low side'.

R&D Costs

- No detailed break-out of the $25M R&D budget.
- 'The Sub-committee regards this level as significantly less than would be needed for a Project of this scale and complexity'.
- RHIC R&D ~8%, SNS R&D ~5% would imply something in the $40M->$60M range for RIA.

Pre-operations costs

- Defined as covering element, subsystem and system commissioning; infant mortality together with M/S and utilities to support these efforts.
- Pre-Ops model had 4 years of funding during the a 6-year construction period.
- Total pre-ops estimate of $150M with a 4-year profile of $20M, $30M, $40M, $60M.
- No detailed back-up or model addressing specific activities available yet.
- RHIC $77M, SNS $102M in pre-Ops funding
- 'The Sub-committee ….. believes that a more thorough analysis of pre-operations costs for RIA would yield a significantly lower value'.

RIA TPC

- RIA Total Project costs:
  - TEC $695M
  - R&D $25M
  - Pre-CDR, CDR & environmental analyses $15M
  - Pre-Ops $$150M

- TPC $885M
  - Does not include site specific savings of ~$50M

Committee's Conclusions

- The TEC as presented is reasonable
- The 32% contingency is judged to be appropriate at this point in the development of the estimate
- The other Project costs (R&D, Pre-ops, conceptual design effort, environmental permits) were not estimated as carefully as the TEC.
- The Pre-operations costs of $150M appear somewhat high
- The R&D costs appear somewhat low
- The operating budget of $65M per year is considered minimal for a national facility of approximately the scale of CEBAF

General Committee Comments

- The Committee noted that full facility overhead rates were used on labour and none on materials. Historically construction projects have used significantly lower O/H rates than this.
- The $94M trust fund allocated for experimental equipment is reasonable for the intended goal.
- Technical design stability is crucial for an accurate cost estimate. We find the design is essentially stable and recent changes have involved scope.
- The technical risk on the major components is low (a few exceptions) with appropriate R&D.
- We do not find any significant omissions from the TEC costs. We find some issues with the TPC.

General Committee comments

- The Committee considers the 6 year schedule to be aggressive and would imply a peak funding level of ~$200M per year.
- Existing facilities at ANL are estimated to save ~$50M. An MSU site is declared to be cost neutral via non-DOE contributions. The Committee finds no reason to disbelieve these statements. Both sites provide significant off-project office buildings.